

XD25/1-R

1972 Catalogue

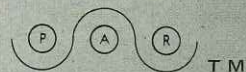
PHYSICS

Printed in U.S.A.

RECEIVED

AUG 25 1972

ARJUP 200



PHYSICS APPARATUS RESEARCH, INC.



FROM THE DESIGNER:

As a physics instructor I frequently found that there was no available apparatus or inadequate apparatus with which my students could experimentally investigate a given phenomenon. It seemed reasonable to assume that other instructors encounter the same difficulties.

I intend for PHYSICS APPARATUS RESEARCH to remove some of these apparatus gaps from physics teaching. This catalogue is the 3rd published by our company and the number of items is steadily growing. There is so much that needs to be done in this area that we anticipate new apparatus will be appearing in subsequent catalogues for a long long time. The acceptance of these items by high schools, junior colleges, and universities has been most gratifying.

The equipment described in this catalogue has been designed especially for use by students. Students break flimsy apparatus, dislike ugly apparatus, and boggle before overly complex apparatus. I have tried to make this apparatus strong, attractive, and simple. I welcome and will personally review your comments on any of our equipment.

Roger D. Stephenson

-
1. **PRICES** - The prices stated in this catalogue are current at the time of printing and every effort is made to maintain these prices for a period of one year from the date of catalogue publication. Price quotes will be provided upon your written request. All prices are F.O.B. shipping point unless otherwise contracted. Stated prices are in U.S. dollars.
 2. **TERMS** - United States and Canada — net 30 days to all educational accounts unless otherwise contracted.
 3. **TAXES** - No taxes have been included in the stated prices.
 4. **SHIPPING** - Method of shipment will be at our discretion unless otherwise specified by the purchaser.
 5. **PACKING** - Packaging for shipment outside the North American continent may require additional protection and crating. These costs are furnished on request.
 6. **BREAKAGE AND SHORTAGE** - When breakage is found on receipt of a shipment: Ask the carrier's agent to inspect the carton and fill out a report. This applies both to visible and concealed damage. Then forward the carrier's report to us and satisfactory adjustment will be made promptly.
 7. **GUARANTEE** - Any apparatus found defective in workmanship or materials within 2 yrs. of purchase will be repaired or replaced without charge. The full purchase price of any item will be refunded within 3 mos. of purchase — your satisfaction is guaranteed.

SOME ADVANTAGES OF PHYSICS APPARATUS RESEARCH EQUIPMENT:

Sturdy Construction - built to last
Carefully designed and manufactured
Experiment guides and directions
Quantitative measurements in a direct manner
Fills some existing gaps in the physics lab

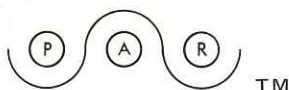
AND —

IT'S NEW AND DIFFERENT

<u>ITEM</u>	<u>PAGE NUMBER</u>
Falling Body Apparatus	4 - 5
Timing Papers	4
Centripetal Force Apparatus	6
Support Stands	7
Low Friction Pulley Assembly	7
Three Dimensional Force Table	8-9
Three D Force Table Adapter Kit	10
Simple Harmonic Motion Spring Set	11
Torque Vector Apparatus	12 -13
Collision Study Apparatus	14 -15
Molecular Motion Study Accessories	16
Newton's Second Law Accessory	17
Variable g Pendulum	18 -19
Ballistic Pendulum	20 -21
Fresnel Lens Kit	22
Driven Harmonic Motion Apparatus	23

Send Purchase Orders to:

U.S.



PHYSICS APPARATUS RESEARCH, Inc.

Designers and Manufacturers of Quality Physics Equipment
P.O. BOX 493 LEE'S SUMMIT, MISSOURI 64063

Canada

MICRO-TEC
Sales and Service

P. O. Box 6611,
Postal Station "G", Vancouver 8, B. C.

FALLING BODY APPARATUS

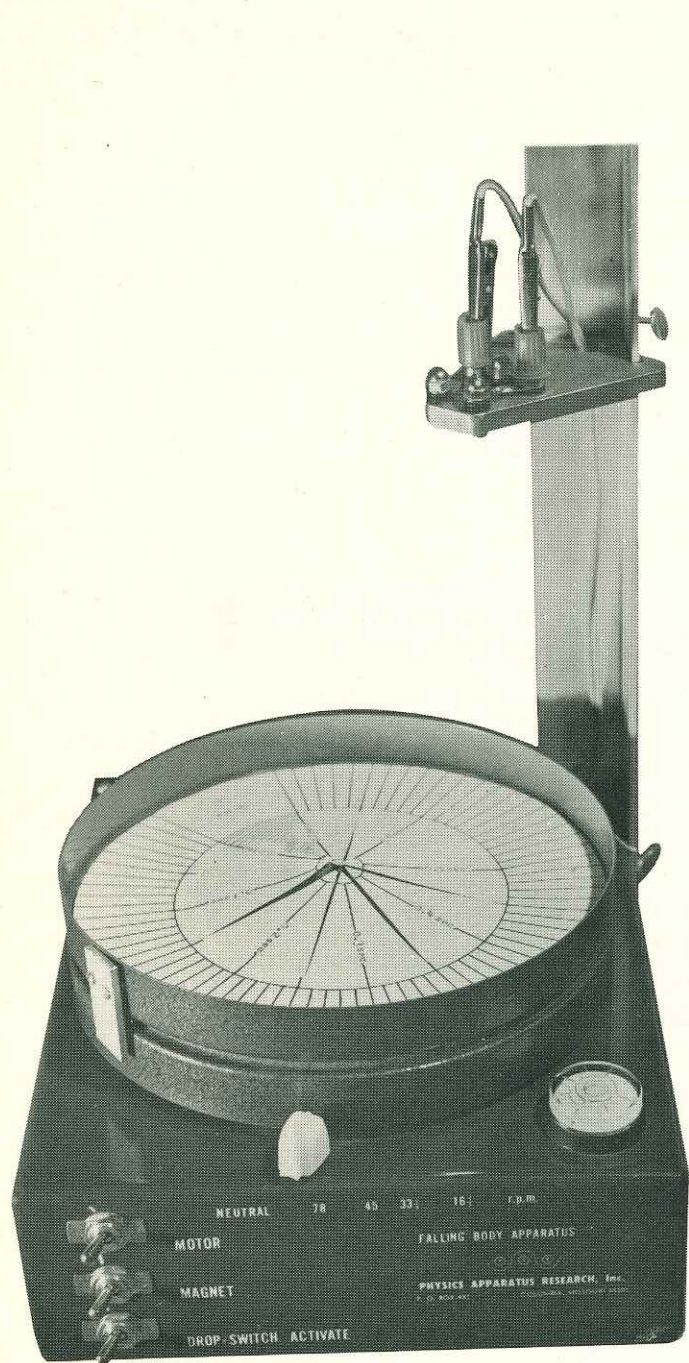
A four speed turntable is used as the precision timer. All of the features necessary to make this apparatus reliable and easy to use are included. Special CIRCULAR TIMING PAPERS have been developed for a rapid read out to hundredths of a second at two different speeds.

It's operation is simple: An AIR CORE ELECTRO-MAGNET holds a small steel ball above the rotating turntable. A micro-switch tripped by a projection on the turntable shuts off the electro-magnet and the falling ball marks the timing paper (through carbon paper). The difference between this mark and one made by turning the table by hand until the micro-switch is tripped shows the time of fall. Data is quickly acquired for graphical or computational analysis of the motion of a body as it accelerates through a distance of one meter or less. Student results in the determination of g consistently show better than 3% precision.

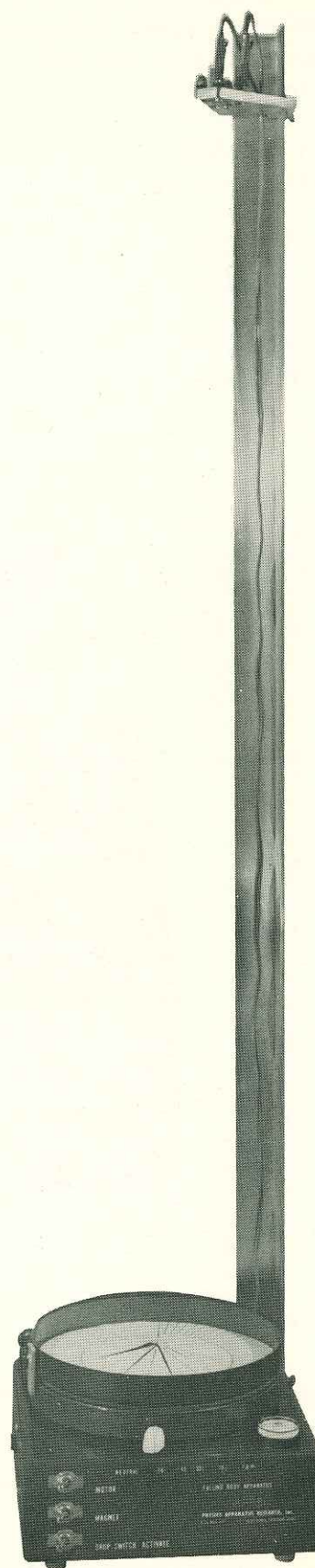
SPECIFICATIONS

- Special design heavy gauge steel cabinet base
- 4-speed, 8" diameter turntable (78, 45, $33\frac{1}{3}$, $16\frac{2}{3}$ rpm)
- 4 switches
 - Motor on-off (toggle)
 - Magnet on-off (toggle)
 - Drop switch (micro)
 - Drop switch activate (toggle)
- Electro-magnet: unique specially designed air-core magnet (no residual magnetism) provides instantaneous release
 - Magnet mount: thick machined aluminum plate protects magnet windings
- Transformer: produces one amp at 6.3 volts for safe electro-magnet power
- Round spirit level
- Three leveling screws
- 6 ft. power cord
- 4 ft. aluminum angle: supports and aligns the electro-magnet at different heights.
- Easily dis-assembles for storage
- Timing papers included:
 - 12 sheets 78 rpm
 - 12 sheets 45 rpm

TO ORDER: Specify No. M105 Falling Body Apparatus Complete		
	Each	\$96.00
	Two or more	92.00
Specify No. M112-78 Additional 78 rpm timing sheets		
	.00 to .70 seconds in .01 divisions (pkg. 25)	\$2.50
M112-45 Additional 45 rpm timing sheets		
	.00 to 1.00 seconds in .01 division (pkg. 25)	\$2.50



Patent Pending



CENTRIPETAL FORCE APPARATUS

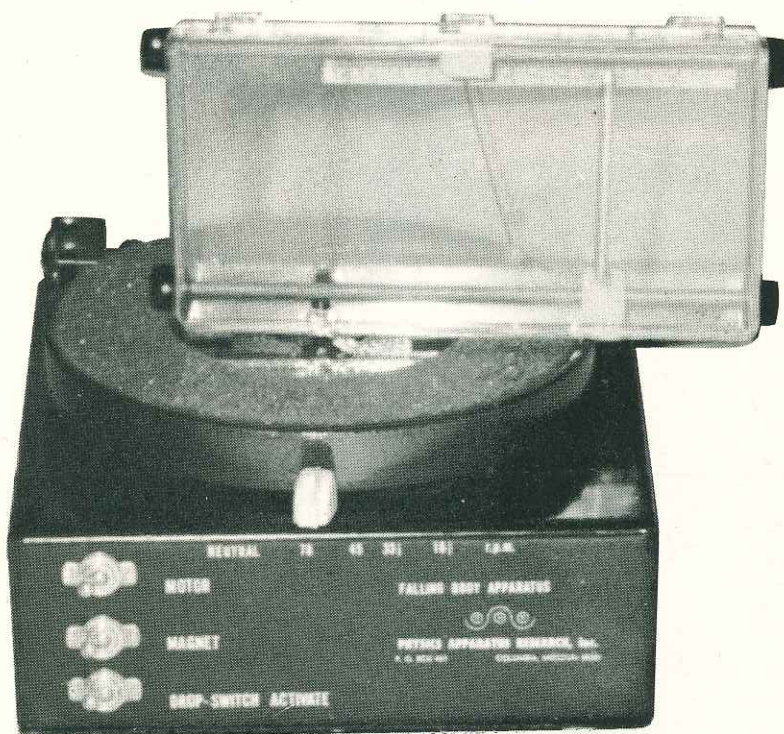
(accessory for falling body apparatus)

This apparatus is composed of a transparent plastic case 5x7x1½ inches containing a moveable pointer, a scale, and a moveable pendulum support and several pendulums. It can be used on the turntable supplied with the falling body apparatus.

The student can change all physical quantities involved: Mass, Velocity, and Radius. Precision of the apparatus: 3%.

The apparatus is securely held to the turntable with magnets. Due to the completely enclosed container, air currents are eliminated.

In the course of the experiment, the student gathers the data necessary to calculate actual centripetal force and the values predicted by $\frac{MV^2}{r}$.



shown attached to our M105
falling body apparatus

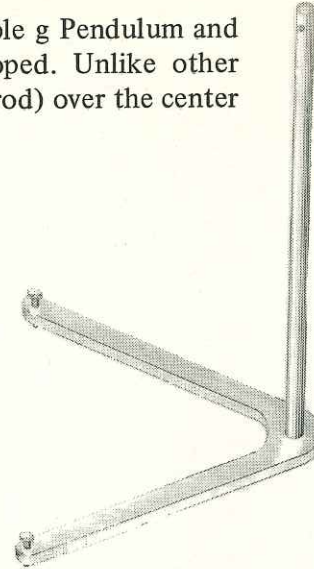
TO ORDER:	Specify No. M106 Centripetal Force Apparatus
	Each\$27.00
	Two or more\$25.00

NESTING SUPPORT STANDS

Because of the added stability needed to support the M110 Variable g Pendulum and the M103 Ballistic Pendulum, a better support base was developed. Unlike other nesting bases and tripod bases, our base supports the load (not the rod) over the center of the base. Leveling screws provide for maximum utility.

SPECIFICATIONS

- ½" thick steel base measures 10½" along each arm
- 19 mm hard aluminum alloy support rods with ½" - 13 shouldered threads to fit base. A hole near the top of the rod allows tightening without special tools.
- two 5/16" x 1½" knurled head screws provide leveling.

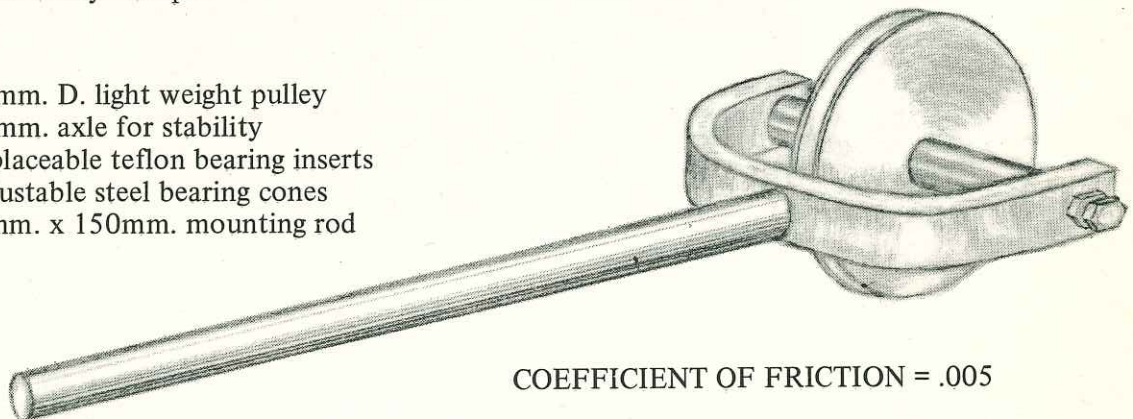


To order Specify No.	Rod Length	5 or Less - Each	6 or more - Each
M 113	30 cm	8.50	8.05
M 114	60 cm	10.00	9.50
M 115	90 cm	11.50	10.95
M 116	120 cm	13.00	12.35

LOW-FRICTION PULLEY

In setting out to build the best force table, we needed the best pulleys. The design that evolved worked so well that we thought you might find other uses for pulleys with such outstanding characteristics. Here then is our "Super Pulley" mounted to fit standard laboratory clamps.

- 50 mm. D. light weight pulley
- 40 mm. axle for stability
- Replaceable teflon bearing inserts
- Adjustable steel bearing cones
- 13mm. x 150mm. mounting rod



COEFFICIENT OF FRICTION = .005

TO ORDER: Specify No. M108 Low-Friction Pulley

Each	\$6.50
Six or more	\$6.00

THREE DIMENSIONAL FORCE TABLE

Force table experiment showing that forces are vectors and that $\vec{F} = 0$ for a body in equilibrium are among the most basic experiments in physics teaching. Unfortunately they are among the duller. By measuring forces in three dimensions the experiments become more interesting, more general, and with the added degree of freedom - more precise.

F_z precision1% F_x & F_y precision2%

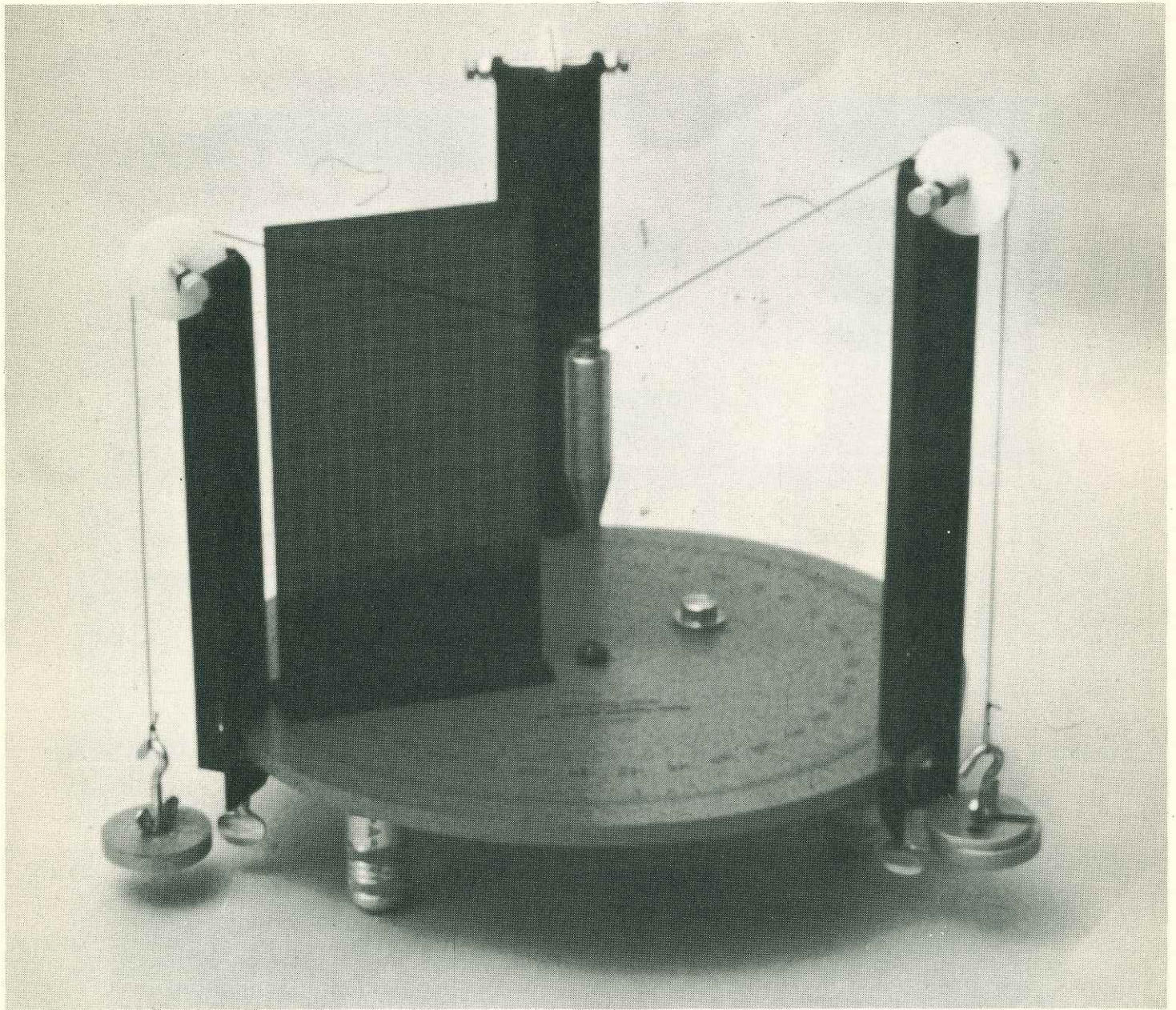
The design of this table makes its operation straight forward while still permitting the student to vary the experiment. The three risers marking the pulley positions in the horizontal plane are moveable and of different lengths for generality and are detachable for easy storage. The ruled vertical plate measures the tangent of the angle that each string makes with the horizontal. Centering of the plumb bob is checked by sighting it and the center pin along the risers. The quality of construction is evidenced by the specifications listed below while such design features as the low center of gravity will be appreciated by any teacher familiar with the physical coordination displayed by some beginning students.

SPECIFICATIONS

- Base: 14" diameter x 3/8" thick steel
- Three risers: 1/8" x 1 1/2" x 1 1/2" angular steel with heights of 10", 11" and 12".
- Three pulleys: Low friction type. (coefficient of friction = .005)
- Plumb Bob: plated steel
- Protractor: 360 degrees with 1 degree divisions.
- Vertical Plate: 1/16" steel plate with grid attached held upright by a steel base.
- Three Legs: 2 1/2" knurled 1 1/4" diameter aluminum leveler.
- Level: Round spirit type.
- Weights and holders not included.

TO ORDER: Specify No. M111 3-Dimensional Force Table

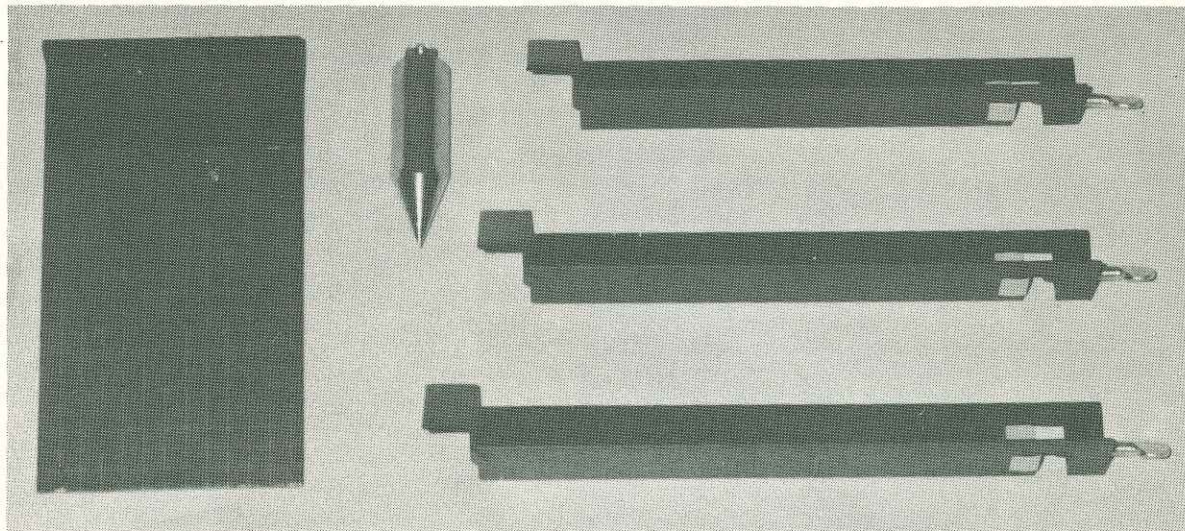
Each	\$90.00
Two or more	\$85.00



THREE DIMENSIONAL FORCE TABLE ADAPTER KIT

Update your two dimensional force tables in minutes with this kit. The risers clamp onto existing tables and existing pulleys clamp onto the risers.

The kit contains risers, plumb bob, and the vertical plate as specified on page 9. Plastic covers prevent metal contact damage to force tables.

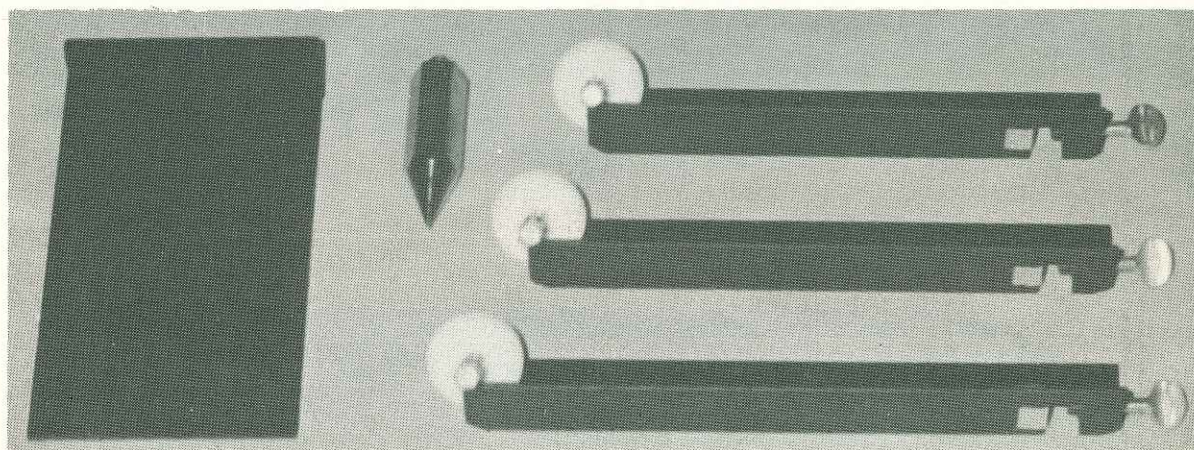


TO ORDER: Specify No. M102 3-Dimensional adapter kit

Each	\$35.00
Two or more	\$32.00

THREE DIMENSIONAL FORCE TABLE ADAPTER KIT WITH PULLEYS

Exact same as above description except this kit contains the pulleys as described on page 7.



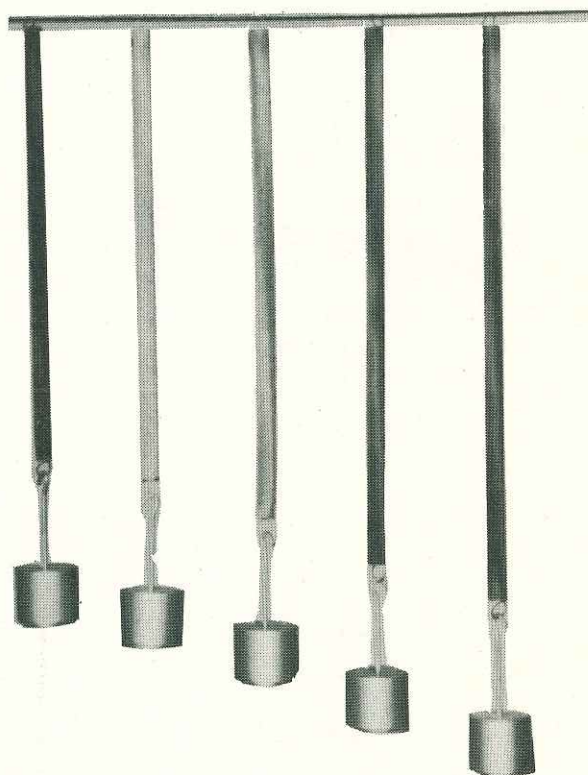
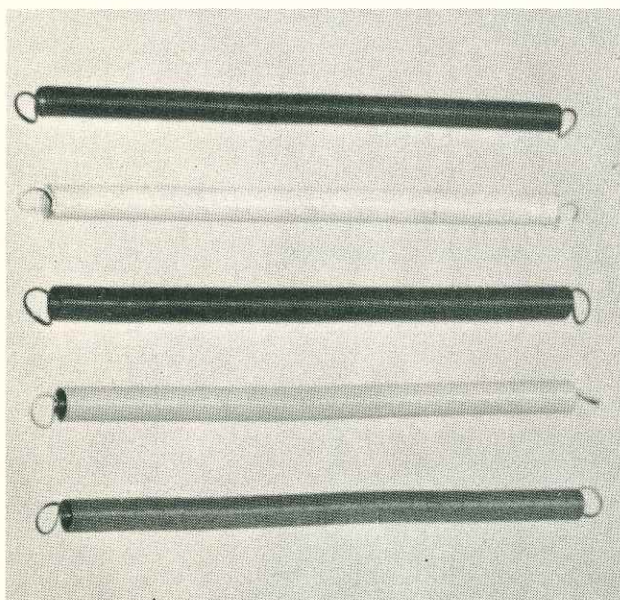
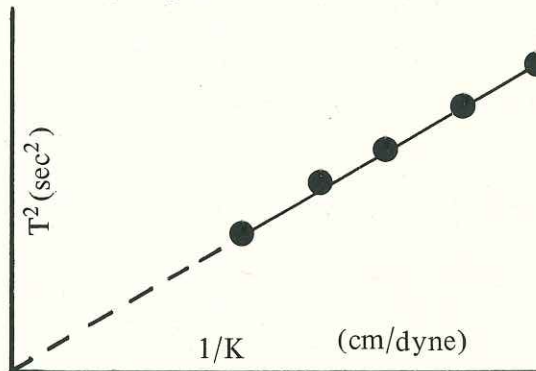
TO ORDER: Specify No. M103 3-Dimensional Adapter Kit With Pulleys.

Each	\$50.00
Two or more	\$47.00

SIMPLE HARMONIC MOTION MATCHED SPRING SET

The period of a mass-on-spring simple harmonic oscillator is a function of both the mass and the force constant of the spring. The dependence on mass is easily checked, but apparatus for accurately investigating the dependence of period on force constant has previously been unavailable. We have developed the apparatus to make the investigation in a simple straightforward learning experience. By using different materials and different tempers, we have produced a set of five springs matched for mass but having appreciably different force constants. To avoid clouding the issue we even made them all the same length and nearly the same diameter.

The springs are 11½" long (unstretched), approximately ½" in diameter, and come in a partitioned box for convenient storage.



TO ORDER: Specify No. M109 S.H.M. Matched Spring Set

Each	\$17.00
Two or More	\$15.00

TORQUE VECTORS APPARATUS

As basic as a force table

This apparatus should have been available a century ago. The treatment of torques as vector quantities is a fundamental part of physics, and yields a NECESSARY concept for the study of gyroscopic precession. Current applications such as spacecraft steering make this topic timely.

In addition to showing that torque is a vector, it shows the second condition of equilibrium in a precise manner, in that calculations are within 2%. Both the direction of the torque vector and $r \sin \theta$ are measured directly. The introduction to cross products provided by this apparatus will be of great value to the student when he later studies electro-magnetism.

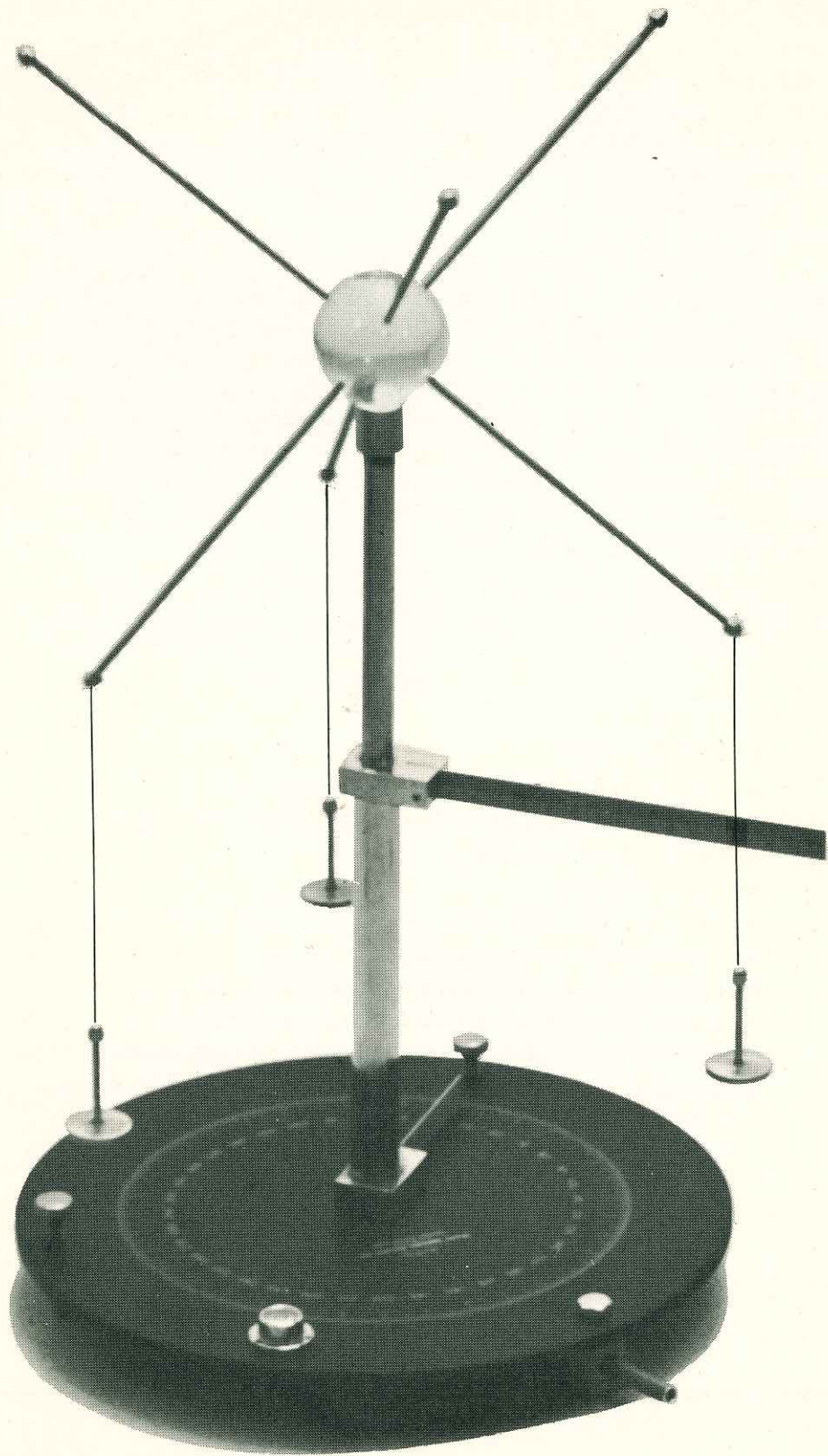
This apparatus is rapidly gaining acceptance in major universities and Junior Colleges across the country. You will be pleased with its extremely attractive appearance and easy to follow experiment guide.

SPECIFICATIONS

- Counterbalanced sphere (torques from weights and holders only)
- Folding lever arm scale coupled to direction indicator
- Leveling screws and round spirit level
- AIR BEARING and pressure bulb are standard and included
- Heavy metal construction throughout except for 2" diameter plexiglass sphere

TO ORDER: Specify No. M101 Torque Vectors Apparatus

Each	\$112.00
Two or more	\$107.00



Patented

COLLISION STUDY APPARATUS

(Shaker Table)

This apparatus is new on the market but has been thoroughly tested by teachers and students. It allows the easy operation and acquisition of the data necessary to calculate momenta and energies before and after collision without the bother of pucks, camera, and strobe. Conservation of momentum and the non-conservation of kinetic energy is easily shown for partially elastic collisions. The vector nature of momentum becomes obvious.

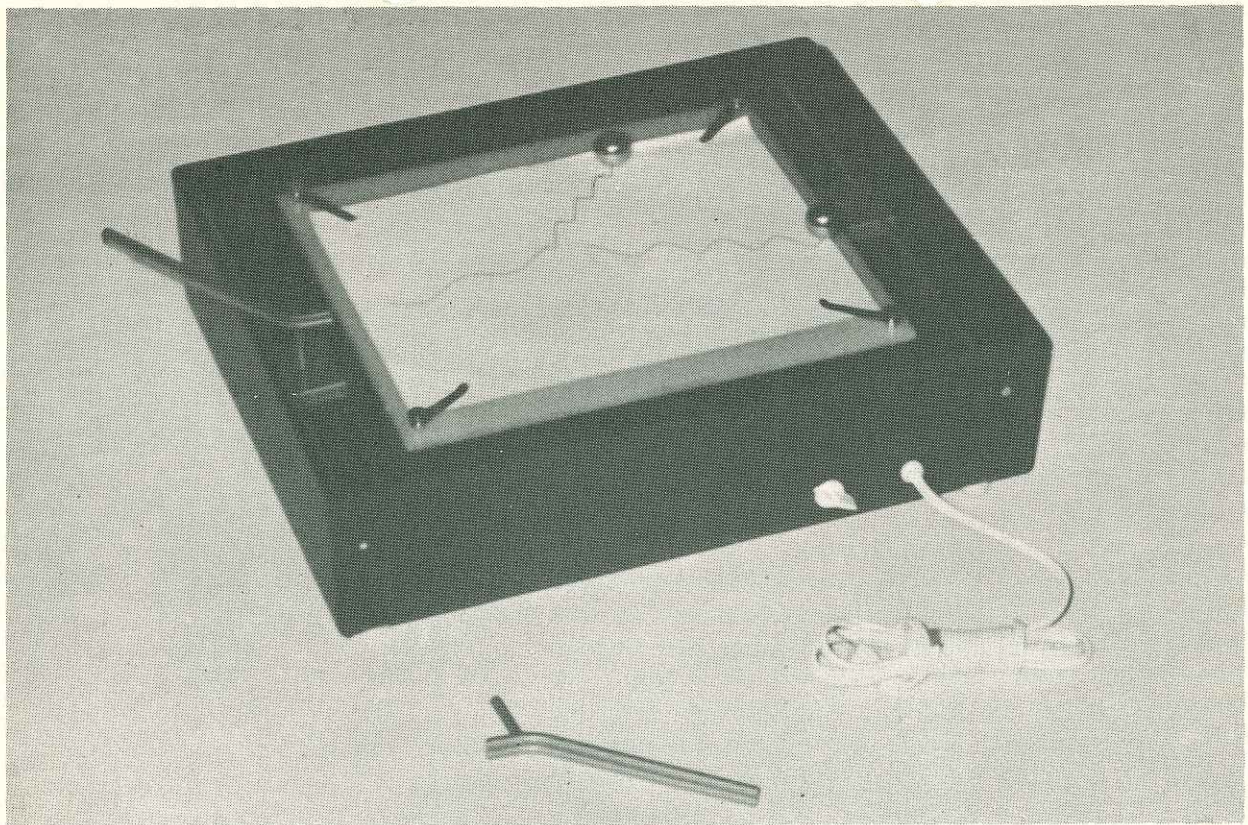
The apparatus uses the periodic motor driven oscillations of a flat horizontal table to time the motions of rolling spheres. The table is covered with a sheet of white paper and one of carbon paper. Spheres rolling on the table leave wave-like motions or tracks through the carbon paper. The linear distance each sphere moves in one oscillation of the table yields the velocity of the sphere. A variety of collisions can be investigated using different mass spheres. (Let one collide with two others). The accuracy of this method is limited slightly by rolling frictions, but conservation of momentum will be established with from one to ten per cent precision. Rolling friction itself can be investigated with the apparatus.

SPECIFICATIONS

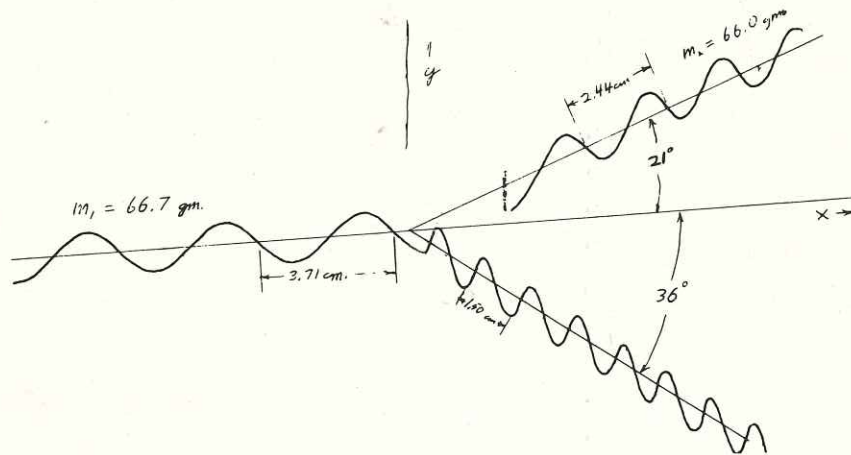
- Leveling screws
- Two moveable pivoting launching ramps.
- Two 5/8 inch and one 3/4 inch steel spheres are included.
- Carbon paper included.
- Easy operation.
- Easy data interpretation.
- Complete instructions included.
- Guards to catch the spheres after collision,
- Allows students to measure distance and time directly.
- Sturdily built 2 speed motor maintains constant oscillation rate.
- Serves as an excellent timer for other experiments (see accessories on pages 16 and 17.)

TO ORDER: Specify No. M104 Collision Study Apparatus

Each	\$95.00
Two or more	\$91.00



Patented



Time Unit = 1 SHAKE

Before Collision

$$\text{Momentum}_x = 66.7 \text{ gm} \cdot \frac{3.71 \text{ cm}}{\text{SHAKE}}$$

$$= 247 \frac{\text{gm cm}}{\text{SHAKE}}$$

$$\text{Momentum}_y = 0$$

Kinetic Energy =

$$\frac{1}{2} \cdot 66.7 \text{ gm} \left(\frac{3.71 \text{ cm}}{\text{SHAKE}} \right)^2$$

$$458 \frac{\text{gm cm}^2}{\text{SHAKE}^2}$$

After Collision

$$66.7 \text{ gm} \cdot \frac{1.5 \text{ cm}}{\text{SHAKE}} \cdot \cos 36^\circ + 66.0 \text{ gm} \cdot \frac{2.44 \text{ cm}}{\text{SHAKE}} \cdot \cos 21^\circ$$

$$81 \frac{\text{gm cm}}{\text{SHAKE}} + 151 \frac{\text{gm cm}}{\text{SHAKE}}$$

$$232 \frac{\text{gm cm}}{\text{SHAKE}}$$

$$66.0 \text{ gm} \cdot \frac{2.44 \text{ cm}}{\text{SHAKE}} \cdot \sin 21^\circ - 66.7 \text{ gm} \cdot \frac{1.5 \text{ cm}}{\text{SHAKE}} \cdot \sin 36^\circ$$

$$57.6 \frac{\text{gm cm}}{\text{SHAKE}} - 58.8 \frac{\text{gm cm}}{\text{SHAKE}}$$

$$1.2 \frac{\text{gm cm}}{\text{SHAKE}}$$

$$\frac{1}{2} \cdot 66.0 \text{ gm} \left(\frac{2.44 \text{ cm}}{\text{SHAKE}} \right)^2 + \frac{1}{2} \cdot 66.7 \text{ gm} \left(\frac{1.5 \text{ cm}}{\text{SHAKE}} \right)^2$$

$$197 \frac{\text{gm cm}^2}{\text{SHAKE}^2} + 75 \frac{\text{gm cm}^2}{\text{SHAKE}^2}$$

$$272 \frac{\text{gm cm}^2}{\text{SHAKE}^2}$$

%
Error

6%

2%

41%

sample collision read-out

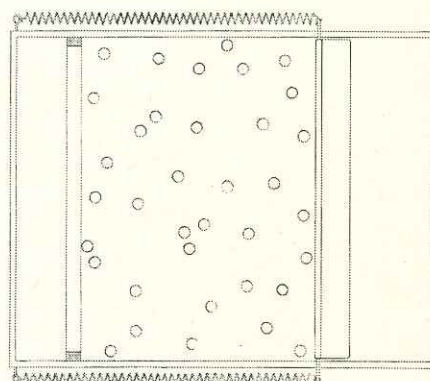
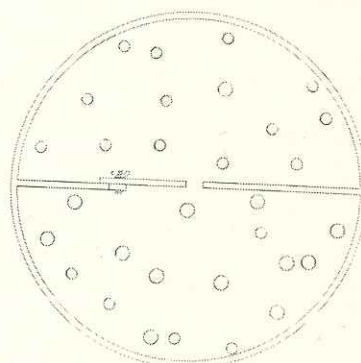
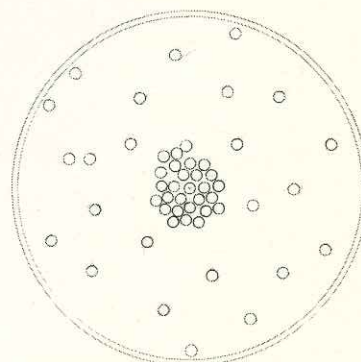
MOLECULAR MOTION KIT — SHAKER TABLE ACCESSORY

This kit is designed to give students a qualitative feel for various molecular phenomena. Each of the three containers partially filled with small spheres and fastened to a shaker table constitutes a two dimensional gas model or liquid-vapor model. The containers fasten to our M-104 shaker table with double stick tape (supplied) and sufficient spheres are provided to perform the experiments described below and others found in the experiment guide.

CONTAINER NO. 1 is used to investigate evaporation and liquification. With the shaker table motor on low speed and a few spheres in the container, the student observes the motion of "molecules" in a "gas." As additional spheres are added, a "liquid drop" forms in the center (as shown). Adding more spheres will increase the size of the drop but not the density of the gas. A model of a liquid in equilibrium with its vapor is thus achieved, and the dynamic nature of this equilibrium is evident. If the "drop" is small, it can be "evaporated" and then reformed by raising and lowering the "temperature" (motor speed).

CONTAINER NO. 2 is divided into halves by a barrier having an adjustable aperture. "Diffusion" through this "semi-permeable membrane" is striking when two sizes of spheres are used and the aperture is set at an intermediate size. Other "osmosis" situations are easily set up and the rates at which equilibrium is established can be found by counting spheres and clock watching.

CONTAINER NO. 3 is designed to permit investigation of the ideal gas laws. The mechanical analogs of P , V , T , and n are easily varied. The container has a moveable barrier for changing "volume" and a spring loaded piston acts as a pressure gauge. The non-ideal situation in which a "liquid drop" has formed and P and V are nearly independent of n is also very interesting.

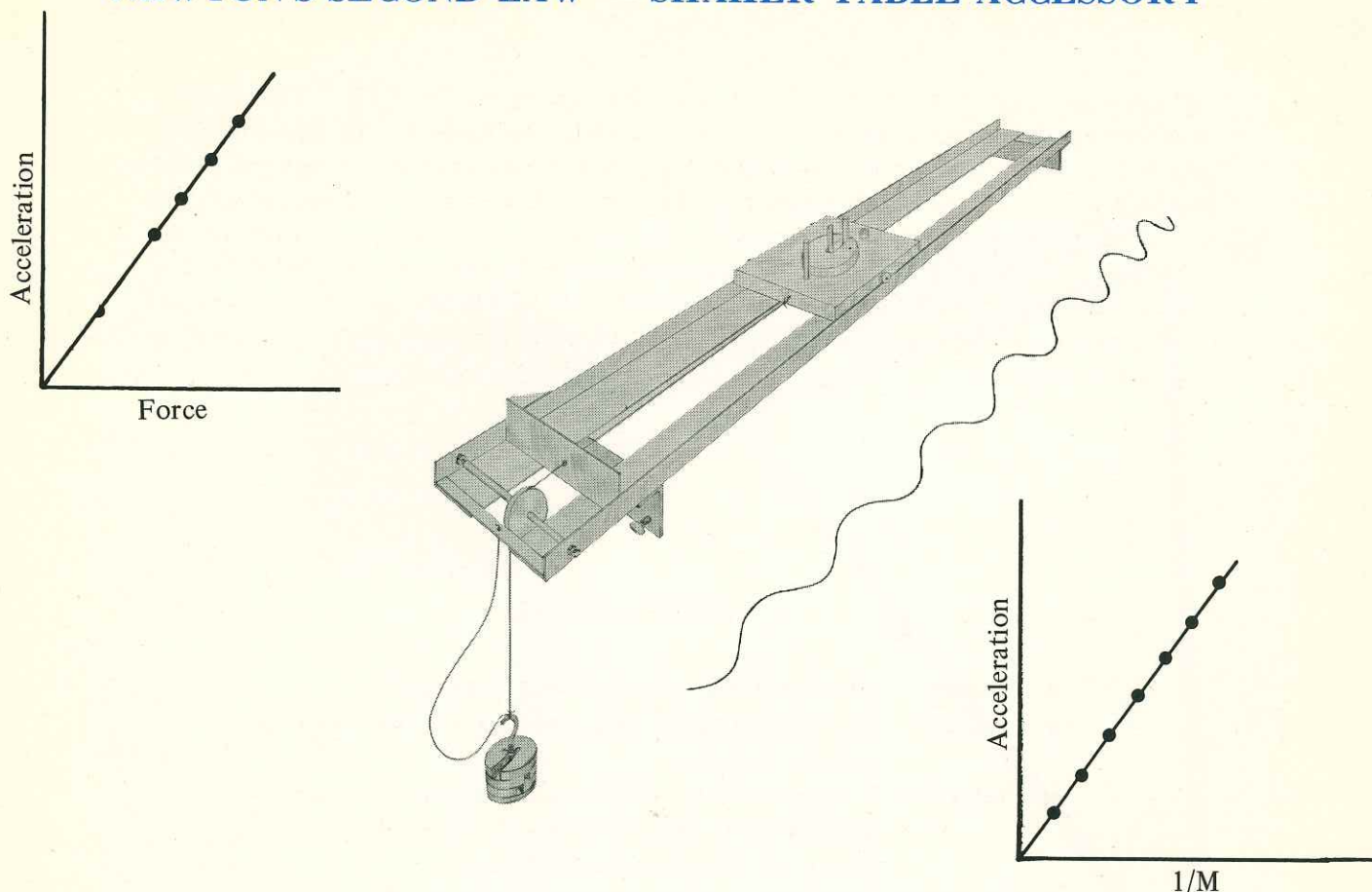


TO ORDER: Specify No. M130 Molecular Motion Kit

Each	\$37.00
Two or more	\$35.00

(For use with M104 Shaker Table)

NEWTON'S SECOND LAW — SHAKER TABLE ACCESSORY



$F = MA$ is probably the most often used equation in elementary physics, yet the equipment available for student experimentation is either too crude to yield good results (PSSC) or too expensive and cumbersome. This accessory attaches to the apparatus shown on the preceding page for simple and unique operation. Calculations are derived from the wave form.

SPECIFICATIONS

- Solid aluminum body carriage moves on three small low friction wheels (one of which floats on its axle)
- Welded steel frame has flat ground rails
- Simple thumb screw attachment to shaker table
- Weight holder has a wing nut that secures slotted weights
- Spring loaded plunger stays in constant contact with the shaker table top.

TO ORDER: Specify No. M120 Newton's Second Law Accessory

Each \$45.00

Two or more \$43.00

(Note: this piece can be used only with our M104 Shaker Table)

VARIABLE g PENDULUM

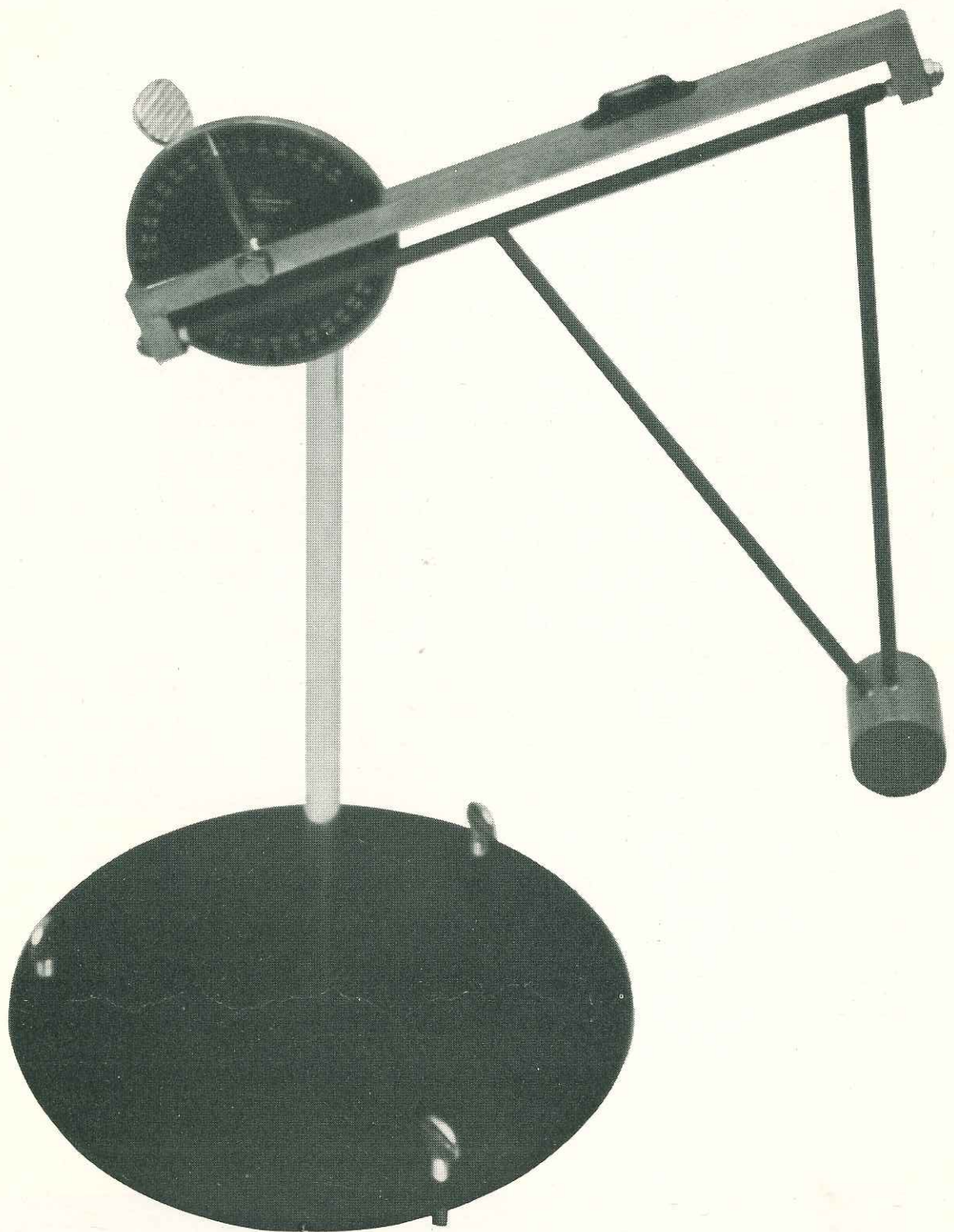
All physicists know that the period of a pendulum is given by $T=2\pi\sqrt{\frac{L}{g}}$. The problem confronting the physics teacher is to cause students to know it. An experiment in which L is varied and T observed is quite easy, but an experiment in which g is varied would seem to call for a rather ambitious field trip. However, by causing a pendulum to swing in a plane at an angle with the vertical, only the component of the gravitational attraction that lies in the plane will affect the swing of the pendulum. The effective g for the pendulum can thus be varied from 980 cm/sec/sec to 0 cm/sec/sec. The apparatus is easy to set up and use, and students find the experiment interesting and challenging.

SPECIFICATIONS

- Bearings: two adjustable, conical, teflon bearings.
- Pendulum: steel bob, support rods, and $\frac{1}{4}$ x 12" axle welded into one rigid piece.
- Protractor: 5" diameter x $\frac{1}{4}$ " thick aluminum plate (1 degree divisions) with hollow steel shaft for mounting in clamp and accepting frame bar axle.
- Frame Bar: 9/16" x 12" polished square aluminum bar with pillow blocks for conical bearings. Bar has spirit level, 4" axle and pointer to indicate angle.
- Heavy Duty Support base, 30 cm. rod and clamp included as described on page 7 of this catalog.

TO ORDER: Specify No. M110 Variable g Pendulum

Each	\$65.00
Two or more	\$62.00



Patent Pending

BALLISTIC PENDULUM

Both the student and the teacher will enjoy the versatility of this piece of equipment. All phases of its operation are outlined in the experiment guide. The following investigations can be accomplished:

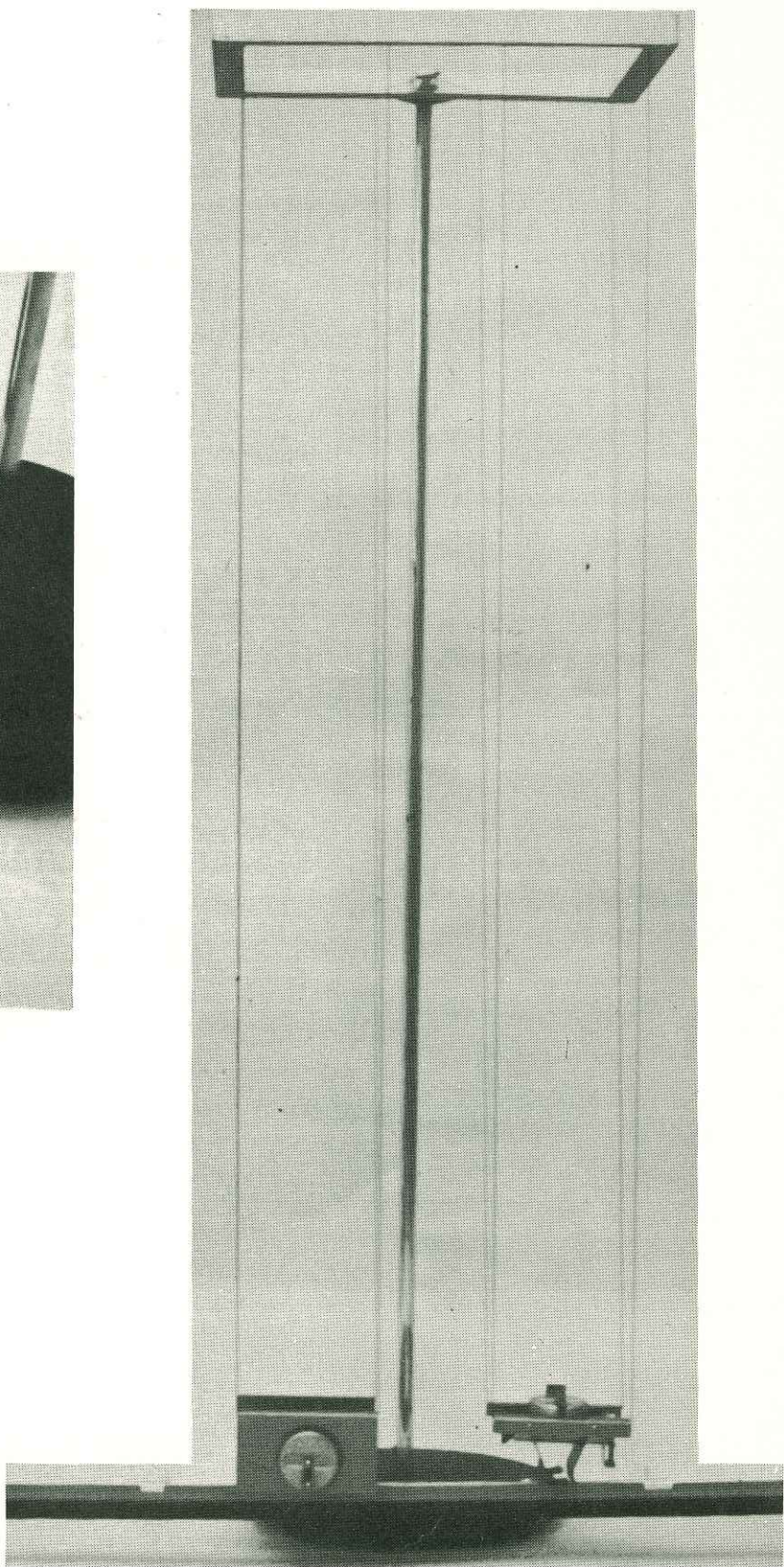
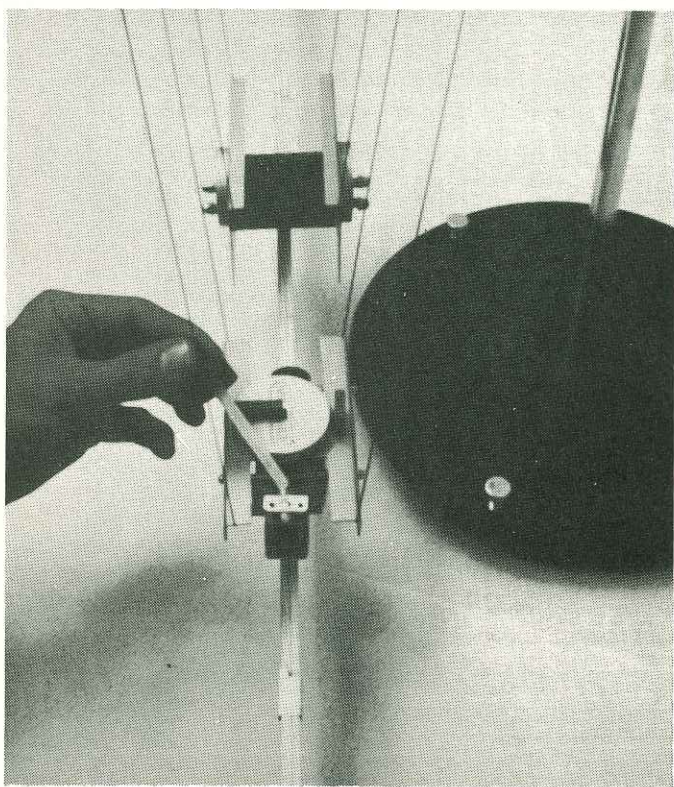
- Momentum is conserved in inelastic collisions
- Momentum is a vector
- Kinetic energy is not conserved in inelastic collisions
- Newton's Third Law (action equals reaction)
- Projectile motion including monkey-hunter Demo

SPECIFICATIONS

- Precision Dart Launcher - Aluminum body barrel with steel trigger mechanism. Smooth and reliable operation. Can be rigged for remote firing by using a water droplet on an ASPIRIN TABLET placed in the trigger mechanism.
- Dart - Massive aluminum bodied dart minimizes effects of air drag. Reliable suction cup tip. Stainless steel used at triggering point to eliminate wear.
- Target Bob - Aluminum hammer tone finish $4 \frac{5}{8} \times 2 \frac{1}{2} \times 2 \frac{1}{2}$ inches. Receives rubber tip dart head on or at a 30 degree angle. Accepts slotted weights to vary the mass. (weights not included). Designed for maximum stability after collision.
- Launcher Bob - Same dimensions and finish as target bob. Holds dart gun securely and accepts slotted weights.
Riders - Two included. Light aluminum construction to slide on meter stick. They mark the extent of each bob's swing.
- Support - Comes equipped with base and 19 mm x 120 cm rod as described on page 7 of this catalog. Overhead support of drilled aluminum angle measures 12" x 15" and conveniently clamps to the support rod.
- Meter Stick Support - A meter stick is supported by an adjustable clamp that is securely fastened to the base. (meter stick not included)

TO ORDER: Specify No. M103 Ballistic Pendulum Complete

Each	\$78.00
Two or more	\$75.00



FRESNEL LENS KIT

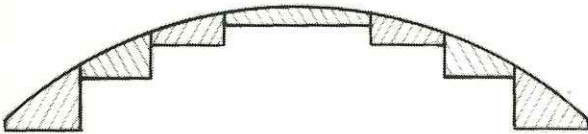
- assembles three ways -

Fresnel lenses are employed in a number of devices the student encounters such as signal lights and overhead projectors. However, students have difficulty understanding how such lenses work by just examining them. We have built a kit that makes the Fresnel lens very easy to understand.

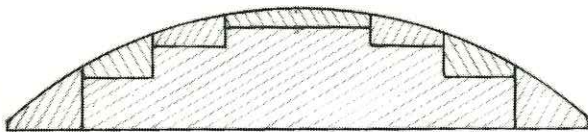
The kit consists of three split rings, a central disk and a stepped pedestal all of clear polished plastic. When the rings are snapped onto the pedestal, an ordinary plano-convex lens results. However, when the rings are removed from the pedestal and snapped onto the disk, a Fresnel lens (curved or flat) is formed. The student is thus able to strip the curved surface from an ordinary lens and assemble it as a Fresnel lens. His measurements will show the focal lengths for all three forms to be nearly the same.



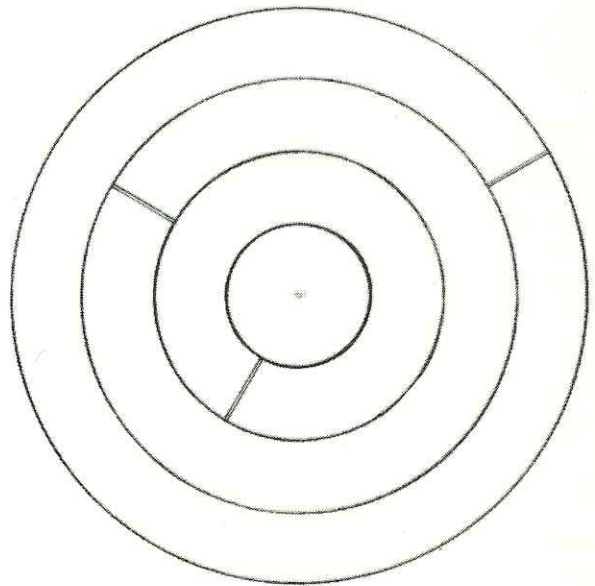
Fresnel Lens - flat form



Fresnel Lens - curved form



Ordinary Lens



actual size

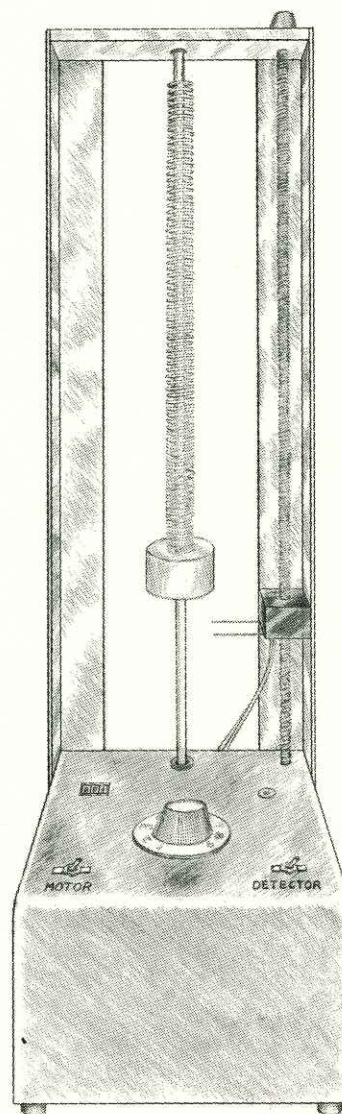
TO ORDER: Specify No. L100 Fresnel Lens Kit

Each	\$23.00
Two or more	\$21.00

DRIVEN HARMONIC MOTION APPARATUS

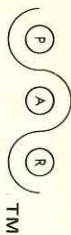
This is a compact machine with deluxe features that permit precise measurement of all pertinent parameters involved in driven harmonic motion. The dramatic effects of phase shift and unlimited amplitude increases as the driver frequency passes through the natural frequency of the oscillator make a striking qualitative demonstration for physical science classes and one of the most interesting quantitative experiments the individual physics student will encounter. Examples of similar phenomena abound in electricity, sound, and mechanics. The experiment guide includes a clearly derived mathematical model of the phenomenon.

- Powerful motor maintains steady driver frequency
- Silicon control rectifier allows driver frequency variation over a wide range without loss of torque
- Three digit revolution counter permits accurate driver frequency determination
- Six volt transformer provides safe power for electric amplitude measurement
- Six volt incandescent bulb gives positive indication of amplitude measurement
- Teflon insert in mass makes friction with guide rod negligible
- Nylon bearings in drive assures long life
- Size: 6" x 8" x 18"
- 115 Volt ac required



TO ORDER: Specify No. M107 Driven Harmonic Motion Apparatus

Each	\$135.00
Two or more	\$129.00



Physics Apparatus Research, Inc.
Lee's Summit, Missouri 64063
Post Office Box 493

ATTENTION: PHYSICS DEPARTMENT

TO:



Bulk Rate
U.S. Postage Paid
Permit No. 7
Sweet Springs, Missouri